

## CLAIM AMENDMENTS

Please replace the pending claims with the following listing of claims:

1-57. (Cancelled)

58. **(Currently Amended)** A wave transmission medium for outputting ~~incident propagating~~ light that is ~~launched into from~~ an input side port (input port) to a desired output side port (output port); to an output port, the input port being defined as any one of a plurality of ports, the output port being defined as at least one of the rest of the plurality of ports, the light at the input port being defined as input-light, and the light at the output port being defined as output-light, each port being defined as a location of a circuit at which a cross section having desired optical input/output is given, said wave transmission medium comprising:

a spatial refractive index distribution determined such that the ~~incident input-light~~ launched into the input port propagates through the wave transmission medium with scattered multiple times and is then outputted from the output port as the output-light;

wherein ~~local positions in the wave transmission medium are~~ the spatial refractive index distribution is designated by ~~virtual~~ each refractive index of pixels defined by a ~~virtual~~ mesh, and

~~the spatial refractive index distribution of the wave transmission medium is formed by refractive indices of the individual pixels~~

said each refractive index of the pixels is determined by repeating calculations until a phase difference between a forward propagation of an input field of the input-light and a reverse propagation of an output field of the output-light becomes less than a desired value at each pixel.

59. (Cancelled)

60. **(Currently Amended)** The wave transmission medium as claimed in claim 58, wherein

[[the]] ~~said each refractive indices-said index of the pixels can take~~ is one of a low refractive index ( $n_L$ ) or a high refractive index ( $n_H$ ), and

said spatial refractive index distribution is given by spatially placing pixels with the low refractive index ( $n_L$ ) and pixels with the high refractive index ( $n_H$ ).

61. **(Currently Amended)** The wave transmission medium as claimed in claim 60, wherein the pixels with the low refractive index ( $n_L$ ) have an existing probability of equal to or less than 30% in a propagation direction of the ~~incident~~ input-light in said wave transmission medium.

62. **(Currently Amended)** The wave transmission medium as claimed in claim 58, wherein

said pixels can take a finite number of refractive indices between a lower limit refractive index and an upper limit refractive index, and

said spatial refractive index distribution is given by spatially placing pixels with the refractive indices selected from among the finite number of refractive indices.

63. **(Currently Amended)** The wave transmission medium as claimed in claim 58, wherein said spatial refractive index distribution is determined such that the ~~incident~~ input-light launched into the input port is split to different output port locations ~~at a desired ratio~~ at different output powers.

64. **(Currently Amended)** The wave transmission medium as claimed in claim 58, wherein

the ~~incident~~ input-light launched into the input port is wavelength division multiplexed light composed of ~~comprising~~ a plurality of wavelengths, and

said refractive index distribution is determined such that the optical waves are demultiplexed to different output port locations depending on the individual wavelengths of the wavelength division multiplexed light.

65. **(Currently Amended)** The wave transmission medium as claimed in claim 58, wherein

the incident input-light launched into the input port is wavelength division multiplexed light ~~composed of comprising~~ a plurality of wavelengths, and

said refractive index distribution is determined such that the wavelength division multiplexed light ~~[[are]] is~~ demultiplexed and split to different output port locations at a desired ratio at different output powers.

66. **(Currently Amended)** The wave transmission medium as claimed in claim 58, wherein

the incident input-light launched into the input port is polarization multiplexed light with a TE mode and TM mode, and

said refractive index distribution is determined such that the polarization multiplexed light is demultiplexed to different output port locations depending on individual polarized waves of the polarization multiplexed light.

67. **(Currently Amended)** The wave transmission medium as claimed in claim 58, wherein

the incident input-light launched into the input port is polarization multiplexed light with a TE mode and TM mode, and

said refractive index distribution is determined such that individual polarized waves of the polarization multiplexed light are demultiplexed and split to different output port locations at a desired ratio at different output powers.

68. **(Currently Amended)** The wave transmission medium as claimed in claim 58, wherein said wave transmission medium ~~is composed of comprises~~ a dielectric.

69-79. **(Cancelled)**

80. **(Currently Amended)** A waveguide circuit that is configured by two-dimensional placement of a wave transmission medium, said wave transmission medium comprising:

a spatial refractive index distribution determined such that ~~the incident input-light~~ launched into ~~[[the]]~~ an input port propagates through the wave transmission medium with scattered multiple times ~~to an output port, the input port being defined as any one of a plurality of ports, the output port being defined as at least one of the rest of the plurality of ports, and the light at the output port being defined as output-light;~~

~~wherein local positions in the wave transmission medium are~~ the spatial refractive index distribution is designated by ~~virtual~~ each refractive index of pixels defined by a virtual mesh, and

~~the spatial refractive index distribution of the wave transmission medium is formed by refractive indices of the individual pixels~~

said each refractive index of the pixels is determined by repeating calculations until a phase difference between a forward propagation of an input field of the input-light and a reverse propagation of an output field of the output-light becomes less than a desired value at each pixel.

81. **(Original)** A waveguide circuit constituting a multimode interference circuit using the waveguide circuit as defined in claim 80.

82. **(Original)** A waveguide circuit constituting an optical bending circuit using the waveguide circuit as defined in claim 80.

83. **(Currently Amended)** An optical circuit configured by using a waveguide circuit that is configured by two-dimensional placement of a wave transmission medium, said wave transmission medium comprising:

a spatial refractive index distribution determined such that ~~the incident input-light~~ launched into ~~[[the]]~~ an input port propagates through the wave transmission medium with scattered multiple times ~~to an output port, the input port being defined as any one of a plurality of ports, the output port being defined as at least one of the rest of the plurality of ports, and the light at the output port being defined as output-light;~~

~~wherein local positions in the wave transmission medium are~~ the spatial refractive index distribution is designated by ~~virtual~~ each refractive index of pixels defined by a virtual mesh,

~~the spatial refractive index distribution of the wave transmission medium is formed by refractive indices of the individual pixels, and~~

~~said each refractive index of the pixels is determined by repeating calculations until a phase difference between a forward propagation of an input field of the input-light and a reverse propagation of an output field of the output-light becomes less than a desired value at each pixel, and~~

the spatial refractive index distribution is implemented by local refractive index variations of said waveguide circuit based on electrooptic effect.

84. **(Currently Amended)** An optical circuit ~~having a waveguide region~~ configured by ~~using a waveguide circuit that is configured by two-dimensional placement of a wave transmission medium, said wave transmission medium~~ on a substrate, the optical circuit comprising:

a wave transmission medium having a spatial refractive index distribution, said spatial refractive index distribution being determined such that the incident input-light launched into [[the]] ~~an~~ input port propagates through the wave transmission medium with scattered multiple times to an output port, the input port being defined as any one of a plurality of ports, the output port being defined as at least one of the rest of the plurality of ports, and the light at the output port being defined as output-light;

wherein local positions in the wave transmission medium are the spatial refractive index distribution is designated by virtual each refractive index of pixels defined by a virtual mesh,

~~the spatial refractive index distribution of the wave transmission medium is formed by refractive indices of the individual pixels, and~~

said each refractive index of the pixels is determined by repeating calculations until a phase difference between a forward propagation of an input field of the input-light and a reverse propagation of an output field of the output-light becomes less than a desired value at each pixel, and

individual refractive indices of said pixels are determined such that the light is confined in a direction perpendicular to said substrate.

85. **(Currently Amended)** The optical circuit as claimed in claim 84, wherein said ~~virtual mesh is composed of configuration elements of a unit cell~~ comprises unit cells that form the waveguide region in periodic repetition.

86. **(Currently Amended)** The optical circuit as claimed in claim 85, wherein each of said unit lattice cells has a quasi-periodic structure.

87. **(Original)** The optical circuit as claimed in claim 84, wherein said pixels can take one of two refractive index values of a high refractive index ( $n_H$ ) and a low refractive index ( $n_L$ ).

88. **(Original)** The optical circuit as claimed in claim 87, wherein said pixels with the high refractive index have a size equal to or less than a wavelength of the light propagating through said waveguide region.

89. **(Currently Amended)** The optical circuit as claimed in claim 88, wherein a value given by the following expression is equal to or less than 0.1,

$$\frac{\lambda q}{\pi a}$$

where

$\lambda$  is the wavelength of the propagation light,

$n$  is the refractive index ( $n_H$ ) of the pixels with the high refractive index,

$a$  is the height of the pixels with the high refractive index, and

$q$  is a coefficient given by  $q = (z/a)$  where  $z$  is an average distance of ~~radiation~~ components gaps between high refractive index areas of the field distribution of the propagation light.

90. **(Currently Amended)** The optical circuit as claimed in claim 87,  
wherein said pixels with the high refractive index ~~[[has]]~~ form a shape of a polygon with  $n$  sides, where  $n$  is an integer equal to or greater than three, and  
wherein said pixels are placed such that the sides each have an inclination with respect to the propagation direction of the light propagating through the waveguide region.

91. **(Original)** The optical circuit as claimed in claim 90, wherein said shape of a polygon is a square, and an angle of the inclination is 45 degrees.

92. **(Currently Amended)** The optical circuit as claimed in claim 87, wherein said pixels with the high refractive index ( $n_H$ ) comprises a waveguiding section including a first high refractive index layer and a second high refractive index layer which are stacked sequentially, said second high refractive index layer having a refractive index lower than the first high refractive index layer; and

said pixels with the low refractive index ( $n_L$ ) comprises a waveguiding section ~~composed of~~ comprising said second high refractive index layer, and

wherein a center of a diameter of the optical field propagating through the waveguiding section of the pixels with the high refractive index ( $n_H$ ) and a center of a diameter of the optical field propagating through the waveguiding section of the pixels with the low refractive index ( $n_L$ ) are both placed on a same plane parallel to a surface of the substrate.

93. **(Currently Amended)** The optical circuit as claimed in claim 84, wherein said pixels each have a desired size equal to or greater than ~~[[the]]~~ a region defined by the ~~virtual~~ mesh, and some of said pixels are placed at locations deviated from lattice locations defined by the ~~virtual~~ mesh.

94. **(Currently Amended)** The optical circuit as claimed in claim 84, wherein said waveguide region is ~~composed of~~ comprises a dielectric material that has an optical loss function or optical amplification function.

95. **(Original)** The optical circuit as claimed in claim 94, wherein said dielectric material has a complex refractive index depending on the wavelength of light.



96. **(Original)** The optical circuit as claimed in claim 84, wherein said waveguide region has a structure comprising

a first low refractive index layer, a high refractive index layer constituting the waveguide section and a second low refractive index layer, which are stacked sequentially, and

wherein the light is confined in said high refractive index layer by the first and second low refractive index layers.

97. **(Currently Amended)** The optical circuit as claimed in claim 96, wherein said high refractive index layer comprises two surfaces, and has, on ~~[[its]]~~ at least one of surface ~~the surfaces~~, relief-like patterning formed by creating concave portions, and wherein

said spatial refractive index distribution is implemented by employing the concave portions as the low refractive index ~~section~~ layer, and regions other than the concave portions as the high refractive index ~~section~~ layer.

98. **(Currently Amended)** The optical circuit as claimed in claim 97, wherein said relief-like patterning is formed on both ~~surface~~ surfaces of said high refractive index layer.

99. **(Currently Amended)** The optical circuit as claimed in claim 98, wherein the relief-like ~~patterns~~ patterning formed on both sides of said high refractive index layer have patterns different from each other.

100. **(Currently Amended)** The optical circuit as claimed in claim 98, wherein said concave portions of the relief-like ~~patterns~~ patterning formed on both sides of said high refractive index layer have a same depth.

101. **(Original)** The optical circuit as claimed in claim 96, wherein at least one of said first and second low refractive index layers is formed by stacking a plurality of layers with different refractive indices.

102. **(Currently Amended)** The optical circuit as claimed in claim 84, wherein said pixels are each divided into a plurality of virtual sub-pixels having one of the high refractive index ( $n_H$ ) and the low refractive index ( $n_L$ ), and said refractive index distribution of the pixels ~~[[are]]~~ is implemented by arrangement of the sub-pixels with the two refractive indices.

103. **(Currently Amended)** The optical circuit as claimed in claim ~~[[84]]~~ 102, wherein in said pixels, a refractive index difference is varied over a distance equal to or greater than one wavelength as a rate of change of the refractive index difference, as a rate of spatial change of a propagation constant in the proceeding direction of a wavefront of the propagation light.

104. **(Original)** The optical circuit as claimed in claim 103, wherein said pixels or said sub-pixels each have a circular cross section in a direction parallel to said substrate.

105. **(Original)** The optical circuit as claimed in claim 103, wherein said pixels or said sub-pixels each have a cross section with a shape of smoothly varying curve in a direction perpendicular to said substrate.

106. **(Currently Amended)** The optical circuit as claimed in claim 84, wherein said optical circuit consists of an optical circuit with a mutual broadcast delivery/broadcast reception configuration having at least three input/output ports, and wherein said spatial refractive index distribution is established such that phases of signals output from said input/output ports are perpendicular at 90 degrees to each other.

107. **(Original)** The optical circuit as claimed in claim 106, wherein a branching ratio of said optical circuit is asymmetric.

108. **(Original)** The optical circuit as claimed in claim 106, wherein the foregoing optical circuit comprises an amplification function.

109. **(Currently Amended)** The optical circuit as claimed in claim 84,  
wherein said optical circuit consists of an optical circuit with a mutual broadcast delivery/broadcast reception configuration having at least three input/output ports, and  
wherein said spatial refractive index distribution is established such that when phases of signals output from said input/output ports are not perpendicular at 90 degrees to each other, overlaps of the output signals become minimum.
110. **(Original)** The optical circuit as claimed in claim 109, wherein a branching ratio of said optical circuit is asymmetric.
111. **(Original)** The optical circuit as claimed in claim 109, wherein the foregoing optical circuit comprises an amplification function.
112. **(Currently Amended)** The optical circuit as claimed in claim 84, wherein  
said optical circuit includes a plurality of input ports, and is configured such that input optical signals launched into the plurality of input ports are output from a same emitting plane, and wherein  
said spatial refractive index distribution is established such that the individual optical signals output from the plurality of input ports have their phases adjusted to be ~~aligned with~~ equal to each other, in order to shape a profile of the output optical field.
113. **(Currently Amended)** An optical circuit having the optical circuit as defined in claim 112 placed at an input side slab of an arrayed waveguide grating circuit, wherein  
mutual phase differences between the plurality of input ports are given by circuit lengths of the optical waveguides of said optical circuit; and  
a repetition period (~~free spectrum range~~) of the phase differences given by the circuit lengths of said optical waveguides agrees with a wavelength spacing of outputs of said arrayed waveguide grating circuit, and centers of fields of the outputs of said optical circuit vary periodically to cancel out chromatic dispersion characteristics of said arrayed waveguide grating circuit periodically at the wavelength spacing of the outputs.

114. **(Currently Amended)** The optical circuit as claimed in claim 84, wherein said spatial refractive index distribution is established ~~such that it implements~~ so as to implement a field profile and phase distribution that enable spot size conversion of the ~~output light~~ output light.

115. **(Currently Amended)** An arrayed waveguide grating type optical multi/demultiplexer configured by using a waveguide circuit that is configured by two-dimensional placement of a wave transmission medium, said wave transmission medium comprising:

- a spatial refractive index distribution determined such that [[the]] incident light launched into [[the]] an input port propagates through the wave transmission medium with scattered multiple times;

- wherein local positions in the wave transmission medium are designated by virtual pixels defined by a virtual mesh,

- the spatial refractive index distribution of the wave transmission medium is formed by refractive indices of the individual pixels, and

- said arrayed waveguide grating type optical multi/demultiplexer comprises

- an input waveguide, a first slab waveguide, arrayed waveguides, a second slab waveguide and output waveguides, which are connected sequentially on a planar substrate; and

- a plurality of scattering points with a refractive index higher than a refractive index of said input waveguide, said scattering points being placed in a connecting region between said input waveguide and said first slab waveguide.

116. **(Original)** The arrayed waveguide grating type optical multi/demultiplexer as claimed in claim 115, wherein said scattering points are disposed such that an optical field distribution formed at an output end of said input waveguide has an iso-phase wavefront without distortion, and an amplitude with double peaks.

117. **(Original)** The arrayed waveguide grating type optical multi/demultiplexer as claimed in claim 115, wherein said scattering points have in said input waveguide a two-dimensional configuration that has nearly line symmetry with respect to a line extending to the propagation direction of light.

118. **(Original)** The arrayed waveguide grating type optical multi/demultiplexer as claimed in claim 115, where said scattering points each have a side equal to or greater than 0.2  $\mu\text{m}$ .

119. **(Currently Amended)** The arrayed waveguide grating type optical multi/demultiplexer as claimed in claim 115, wherein

said planar substrate ~~consists of~~ comprises a silicon substrate, and

said optical waveguides ~~consist of~~ comprise silica-based glass optical waveguides.

120. **(New)** An arrayed waveguide grating type optical multi/demultiplexer comprising:

an input waveguide, a first slab waveguide, arrayed waveguides, a second slab waveguide, and output waveguides connected sequentially on a planar substrate, and

a wave transmission medium having a spatial refractive index distribution, said wave transmission medium being placed in a connecting region between said input waveguide and said first slab waveguide, said spatial refractive index distribution being determined such that input-light launched into the input waveguide propagates through the wave transmission medium with scattered multiple times to the first slab waveguide as output-light;

wherein the spatial refractive index distribution is designated by each refractive index of pixels defined by a mesh, and

said each refractive index of the pixels is determined by repeating calculations until a phase difference between a forward propagation of an input field of the input-light and a reverse propagation of an output field of the output-light becomes less than a desired value at each pixel.

121. **(New)** The arrayed waveguide grating type optical multi/demultiplexer as claimed in claim 120, wherein an output field of the output-light is disposed such that an optical field distribution has an iso-phase wavefront without distortion, and an amplitude with double peaks.

122. **(New)** The arrayed waveguide grating type optical multi/demultiplexer as claimed in claim 120, wherein a pattern of the pixels in the wave transmission medium has nearly line symmetry with respect to a line extending to the propagation direction of light of the input waveguide.

123. **(New)** The arrayed waveguide grating type optical multi/demultiplexer as claimed in claim 120, where the length of each pixel is equal to or greater than  $0.2\ \mu\text{m}$ .

124. **(New)** The arrayed waveguide grating type optical multi/demultiplexer as claimed in claim 120, wherein

said planar substrate comprises a silicon substrate, and

said optical waveguides comprise silica-based glass optical waveguides.